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# *THE PLACE OF SCIENTIFIC AND TECHNICAL SCHOOLS IN AMERICAN EDUCATION.*[1]

By FRANCIS A. WALKER, President of the Institute.

Among the vast changes in the spirit and life of our country, in the arts, the industries, the ideas, the aspirations, of the American people, which were brought about by, or which coincided with, the great struggle from 1861 to 1865, none is more remarkable than the rapid development of schools of applied science and technology. It is no part of my duty to name even the most important of these, or to attempt to divide among them the honor of what they have, as a whole, achieved. I shall confine myself to accounting, as far as I may, for the rapidity with which these schools have spread over the land, and to estimating their place in our educational system.

The nearest and easiest thing to say regarding the growth of scientific and technical schools, since the fortunate conclusion of the civil war, is that the industrial development of the country had reached the point where it had become necessary that the enterprises into which our labor and capital were to be put should be organized and directed with much more of skill and scientific knowledge than had been applied to our earlier efforts at manufactures and transportation; and so, in the fullness of time, scientific and technical schools came. In this view there is much of truth. The vaster enterprises of these later days, the ever increasing possibilities of modern commerce and industry, the intensifying severity of competition due to quickened com-

[1] Address at the Convocation of the University of the State of New York, Albany, July 9, 1891.

munication, fast mails, cheap freights and ocean cables, had indeed created an urgent want for greater technical skill and more highly trained intelligence. The old wasteful ways of dealing with materials, the rule-of-thumb methods of construction, the haphazard administration, characteristic of our earlier industrial efforts, could not have been continued without greatly retarding the national development and without irreparable loss in the result. But not, at the time spoken of, had this want become one of which our people were generally conscious; much less had it created a demand for such institutions which would of itself have sufficed to bring them into existence. The establishment of scientific and technical schools in the United States was to constitute a striking instance of the principle that, in some things, supply must create demand.

Economists and people generally are so much accustomed to think of the more usual condition in which demand creates supply, that they often forget — indeed, to many it never occurs — that there is another large class of cases, and these far the most important of all, in which the opposite rule obtains. In the lower ranges of life, in matters of clothing, food and shelter, and indeed in holding on to whatever advances civilization has once fairly and fully made, whether in material or in higher things, the conscious wants of humanity will in all ordinary cases suffice to secure the due supply, without any organized public or private effort other than that originating in personal interest. But in all things high and fine, and generally also in every advance which material civilization is to make, there must be a better intelligence than that of the market, which shall apprehend, not what the people want, but what they ought to want; there must be disinterested efforts on the part of the natural leaders of society, which shall secure, at whatever sacrifice, such a demonstration of the merits and advantages of the yet unknown thing, such a supply of the new good, as shall create the demand for it. It will not be until that want has been fairly and fully wrought into the public consciousness, that the supply may thereafter be left to take care of itself.

The American schools of technology illustrate in an eminent degree the law of human progress which I have stated. These schools did not come into existence in obedience to a demand for them. They were created through the foresight, the unselfish devotion, the strenuous endeavors of a few rich men, and of many very poor men, known as professors of mathematics, chemistry, physics, and geology. At the

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time they came into existence there was a smaller demand for technically trained men than there is today, when for twenty-five years these schools have been pouring out their hundreds of graduates annually. That demand has been created by first furnishing the supply; by showing what young men properly educated and highly trained can do in organizing and directing the forces of American industry.

That these schools, in spite of the fact that they had everything to do at once and little to do it with; in spite of the fact that they had no traditions to govern them, and had, indeed, the whole philosophy of their subject to evoke, *a priori;* in spite of general public indifference and even of much contempt, have done their work exceedingly well, even from the first, is fairly implied in the foregoing statement. It is truly remarkable that, with so little to go by and so much to do, all at once, out of such scanty means, there should have been so little waste of effort, so little done injudiciously, so few steps taken that needed to be retraced.

Credit should also be given to the Congress of the United States for the act which was passed July 2, 1862, under the enlightened leadership of the Hon. Justin S. Morrill, of Vermont, making generous provision for the establishment, in the several States, of colleges of agriculture and the mechanic arts. Most of this provision was, it is true, devoted to the creation of agricultural schools, regarding which the scope of this address does not require me to speak, and, indeed, regarding which I should scarcely presume to express an opinion; yet the part which was assigned to the promotion of the mechanic arts proved to be a most valuable and timely reënforcement of the American system of technological schools.

But no one who thoroughly believes in the mission of schools of this class can be content merely to assert that the full time had come in the economic evolution of the nation when such schools were imperatively needed for the promotion of our industries, and that the institutions thus called into being have done this, their primary work, with triumphant success. We go far beyond this, and assert for these schools that they have come to form a most important part of the proper educational system of the country, and that they are today doing a work in the intellectual development of our people which is not surpassed, if indeed it be equaled, by that of the classical colleges. No statement less broad and strong than this would begin to do justice to the view we take of what these schools are now doing, and are in an

increasing measure to do, for the manhood and citizenship of the country. We believe that in the schools of applied science and technology as they are carried on today in the United States, involving the thorough and most scholarly study of principles directed immediately upon useful arts, and rising, in their higher grades, into original investigation and research, is to be found almost the perfection of education for young men. Too long have we submitted to be considered as furnishing something which is, indeed, more immediately and practically useful than a so-called liberal education, but which is, after all, less noble and fine. Too long have our schools of applied science and technology been popularly regarded as affording an inferior substitute for classical colleges to those who could not afford to go to college, then take a course in a medical or law school, and then wait for professional practice. Too long have the graduates of such schools been spoken of as though they had acquired the arts of livelihood at some sacrifice of mental development, intellectual culture, and grace of life. For me, if I did not believe that the graduates of the institution over which I have the honor to preside were as well educated men, in all which the term "educated man" implies, as the average graduate of the ordinary college, I would not consent to hold my position for another day. It is true that something of form and style may be sacrificed in the earnest, direct, and laborious endeavors of the student of science; but that all the essentials of intellect and character are one whit less fully or less happily achieved through such a course of study, let no man connected with such an institution for a moment concede!

That mind and manhood alike are served in a preëminent degree by the systematic study of chemistry, physics, and natural history, has passed beyond dispute. The haste with which the colleges themselves are throwing over many of their traditional subjects to make room for these comparatively new studies, shows how general has become the appreciation of the virtue of these, when combined with laboratory methods, as means of intellectual and moral training.

I have spoken of the characteristic studies of these schools as the best of all available means of both moral and intellectual training. I believe this claim to be none too broad.

1. The sincerity of purpose and the intellectual honesty which are bred in the laboratory of chemistry and physics, stand in strong contrast with the dangerous tendencies to plausibility, sophistry, casuistry, and self-delusion which so insidiously beset the pursuits of metaphys-

ics, dialectics, and rhetoric, according to the traditions of the schools. Much of the training given in college in my boyhood was, it is not too much to say, directed straight upon the arts which go to make the worse appear the better reason. It was always an added feather in the cap of the young disputant that he had won a debate in a cause in which he did not believe. Surely, to an audience in these more enlightened days it is not needful to say that this is perilous practice, if, indeed, it is not always and necessarily pernicious. Even where the element of purposed and boasted self-stultification was absent, there was a dangerous and a mischievous exaltation of the form above the substance of the student's work, which made it better to be brilliant than to be sound.

Contrast with this the moral and intellectual influence of the studies and exercises we are considering. The student of chemistry or physics would scarcely know how to defend a thesis which he did not himself believe. In that dangerous art he has had no practice. The only success he has hoped for has been to be right. The only failure he has had to fear was to be wrong. To be brilliant in error only heightened the failure, making it the more conspicuous and ludicrous. How wholesome to the mind and heart of the pupil is such a regimen!

2. Again, in addition to the graces of sincerity and intellectual honesty, which are the proper traits of physical and natural science; altogether aside, too, from any future technical uses to which the arts or the information acquired may be put, there is great virtue, as training for practical work in life, of whatever kind, in whatever sphere, to be found in the objective study of concrete things, which so largely makes up the curriculum of the schools we are considering.

3. Still another advantage which we claim for the characteristic studies of the new schools, is that, in a very large degree, they dispense with the system of examinations which has become the curse of modern education. The recent remarkable outburst in England, from educators of every name and class, against that system, justifies the strong terms I have used. It is admitted on all sides to be a problem of the greatest difficulty so to adjust the scheme of examinations that they shall not largely neutralize the good effects of sincere and straightforward study.

So far has cramming been carried in English universities, and even in our own colleges, that examinations have largely ceased to be a test

of the scholar's attainments, much more of his real proficiency in his studies. Students who have a marked facility in this sort of thing acquire, in time, the faculty of passing creditably examinations on matters of which they know almost absolutely nothing. By steadily cramming for a few days and nights, under artful coaches, who know the professors' weaknesses and fads, a young man exceptionally expert can "get up" a subject,[1] of which he would be troubled, the morning after examination, to give an intelligible account. A special organ — the examination organ — becomes developed, which is as specific as the water-sacks attached to the stomach of a camel, intended only to carry a certain amount of refreshment over a very dry place for a very short time. Indeed, the comparison fails to do justice to its subject. The examination organ is at once as specific and as external as the pouch of a kangaroo.

From this serious difficulty, schools of applied science and technology are, by the very nature of the case, largely freed. Indeed, the inapplicability of the scheme of examinations to the studies we are considering has even been made an argument against their introduction into universities. Prof. Parsons Cooke, in addressing a body of students at Harvard recently, said: "When advocating in our mother university of Cambridge, in Old England, the claims of scientific culture, I was pushed with an argument which had very great weight with the eminent English scholars present, and which, you will be surprised to learn, was regarded as fatal to the success of the natural science triposes then under debate. The argument was, that the experimental sciences could not be made the subjects of competitive examinations."

It is not true that chemistry and physics cannot be made the subject of examinations AFTER THEIR KIND; but it is true that, under competent teachers of these sciences, examinations have far less of the character of a cram, and far more of the character of a test of ability to do work. Moreover, in such a scheme of instruction, as a whole, examinations perform a much less important part, while the daily and

[1] I would not disparage the importance, as a professional accomplishment, of the ability to "get up" a subject in a very short time under high pressure. A lawyer has often occasion to do this very thing. But this is a professional accomplishment, and should be acquired as such. The period of professional study is not too late for the acquirement of this faculty. It can even be acquired later still, in the course of professional work. Such practice, however, in my judgment, forms no part of general education and training, and is only vicious and mischievous in the culture stage.

weekly exercises in the laboratory become continually of more and more account as a means of ascertaining the scholar's real progress. In this the schools of applied science and technology comply with the demands of modern thought in pedagogics. In no department of life more than in education is the Scripture precept of authority, "Let the dead bury their dead." The best examination which a student can pass is by showing his ability to *do the next thing*. If he can pass this examination successfully, the teacher need give little thought to what has gone before. And I venture, by the way, to suggest, with reference to the urgent inquiry now proceeding as to where the American youth loses two years of time in his preparation for college, whether a large part, if not the whole of that serious loss, is not sustained from the everlasting reviews and examinations through which the American teacher, alike in the primary, the grammar, and the high school, insists upon dragging the pupil three times a year or oftener, not only requiring him thus to be continually going over again ground once traversed, but, what is of more consequence, creating a sentiment throughout the school-room which inspires the scholars to be forever looking back, and not forward.

4. The last of the advantages attendant on scientific instruction which I shall enumerate, though the list might be still further extended, is found in a better relation between teacher and pupil. I would not willingly be guilty of exaggeration in this matter. With a really great and gifted teacher, the attitude of the scholar will always be that of respect and admiration, whether with or without affection and personal intimacy. But it cannot be denied that, in the traditional college, with the traditional subjects of instruction, the relation in question is likely to be less than a happy one. On the one side there is apt to be an undue assumption of knowledge, a tendency to dogmatism, and a too peremptory way of dealing with the pupil's doubts and difficulties. On the other side there is apt to be something of the tone of resistance, if not of resentment; a disposition to escape the teacher's scrutiny, if not to get around him with the petty tricks of the recitation room.

It would be foolish to assume that there is any virtue in the natural and physical sciences which will overcome the faults or deficiencies of mind and heart that are found in some teachers. There are men who will be priggish, pompous, and pretentious in doing anything. But there is a wonderful virtue in the studies we are considering for bringing teacher and scholar together in their work in a most simple, natu-

ral, and affectionate relation. He is the most successful teacher of science who puts himself in the attitude of discovering truth with his pupil, and of hunting with him for the object of their common search. Moreover, the very closeness of the contact in the laboratory of chemistry, physics, or mechanics, is such as to cause a continuous, insensible discharge of the electricity generated by the necessarily strict requirements of study and discipline, and thus to maintain the friendly relations of teacher and pupil, unbroken by those storms which sometimes gather and burst in colleges where the teacher sits, buttoned-up, on a platform, behind his desk, and lectures to his pupils from the chair of authority.

But it may be said: Considering all that may be claimed for the purely educational advantages of the scientific studies which run through the curriculum of the technological schools, why may not all these advantages be equally obtained by the student of the traditional college, and even to better effect, since there he may secure the pure gold of truth freed from the alloy of baser metal — by which term the critic would designate the useful, practical applications of science. It is here that it behooves us to take issue, most directly and aggressively, with those who assert for the old-fashioned colleges an educational virtue superior to that of the schools we represent. It is of the very essence of our case that the directness and immediateness of application to which the studies of our pupils are subject, under their very eyes and at their very hands, constitutes a tremendous educational force, securing a closeness and continuity of attention on the part of the pupil, an earnestness of effort, a zeal and enthusiasm of work, which it is utterly beyond the power of the teacher of classics or philosophy to arouse, except in the case of gifted students. If proof of this upon a large scale be needed, it is enough to refer to the well-known fact that law schools and medical schools invariably command the energies of their pupils in a far higher degree than do the colleges; and that hosts of young men who have idled and dawdled away the four years nominally devoted to classics and philosophy throw themselves with splendid enthusiasm into their professional studies when once they, for the first time, see upon what ends their efforts are directed, and how their energy and application are to promote their happiness and usefulness in life.

Even in the case of those young men who need no such incentive to secure their faithful attention and earnest endeavor, we yet hold

that schools of applied science and technology possess a distinct advantage, in that their students learn the truths of science in a somewhat different way, and, in the result, know them somewhat better than do those who study these truths, no matter how diligently, without immediate, direct, and constant reference to their applications. Without referring further at this point to the limitations and defects inherent in all academic systems of recitation and examination, I believe it to be true that the man who, in studying mathematics, for example, has only to look forward to a recitation tomorrow and an examination two weeks or two months hence, applies himself to the subject necessarily in a different spirit and also necessarily with an inferior result, in contrast with the man who, continually as he acquires his mathematics, puts it to use day by day in the laboratory of physics, mechanics, hydraulics, or steam engineering.

For these reasons we must decline to accept the characterization of the technical applications of science as the alloy which debases the pure gold of truth. We look upon them, the rather, as the tough, elastic bow which sends the keen shaft to its mark. And, be it remembered, zeal and enthusiasm of work are not to be valued merely because, or merely as, they secure directness of attention, continuity of application and sustained endeavor. In themselves, of themselves, they are in a high sense an educational force, telling immediately and telling powerfully upon intellect and character, contributing importantly to build up mental and moral substance firmly and healthily.

There is one school in the United States mainly devoted to the application of scientific principles to a professional art, which is so well known to all our people, and whose work in the development of mind and manhood has been so severely tested in the sight of the country and of the whole world, that I cannot forbear to allude to it here. I mean the Military Academy at West Point. There is no reason to believe that, for the thirty years preceding the civil war, the young men who went to that school were in any degree superior to those who entered Yale or Harvard. Indeed, there was at that time, at least throughout the North, a certain disinclination on the part of the more generous and ambitious of our youth to adopt the career of arms. Yet when the war broke out, what a wealth of intellect and character was displayed by the graduates of that one small school during the terrific trial to which they were instantly and without preparation subjected! Think how many men from that single academy, which had fewer

living graduates than either Amherst or Williams, led army corps and armies with distinction, on the one side or the other, in what was perhaps the greatest war of modern history! I said "of intellect and character," for it is character, even more than intellect, which enables the commander to bear the tremendous cares, responsibilities, and burdens of his office. What was it which, out of those few small classes of raw lads, developed a Grant, a Lee, a Sherman, a Meade, a Jackson, a Thomas, the two Johnstons, a Hancock, a Reno, a Reynolds, and a Sheridan, not to mention scores of others who "waxed valiant in fight" and commanded divisions and corps with a skill and address which have excited the admiration of the professional soldiers of Europe? Doubtless in some part it was the romance and the highly stimulating influences of the military career. Doubtless in part also it was the special inspiration of the tremendous occasion, fraught as that was with the destinies of a continent. But I believe it, in still greater part, to have been the perfectly natural effect of the application of perhaps not extraordinary powers to the thorough, patient, unremitting study of scientific principles, directed straight upon a worthy profession, under the tuition and guidance of renowned masters of that art, and under the constant influence of professional ideas, professional sentiments, and great professional examples.

A great deal more might be said in comparison of the influence of scientific teaching as carried on in the schools of applied science and technology, with the influence of the traditional, or of the more modern, modified, curriculum of the classical colleges; but perhaps enough has been said to justify the assertion that the former class of institutions are just as truly educational as the latter. Here I am content to rest my case. This conceded, let the youth of the land seek the one or the other kind of school, according to their individual tastes, predilections, and plans for life. I am far from being so bigoted as to suggest that there is not room enough in the educational system of the future for all the institutions of the elder type which have achieved for themselves a name in letters and philosophy; which have, with pains inexpressible, wrought out their own problems and created their own constituencies; and each of which has a host of eager, devoted alumni, ever turning gratefully to the halls in which they were nurtured, and delighting to give to the old college the fruit of their labors and the fruit of their loins. But I confidently look to see a largely disproportionate number of the new institutions which shall from time

to time come into being, built essentially upon the plan which has achieved such prodigious successes during the quarter-century now closing. Doubtless the present general scheme of the schools of technology will itself undergo considerable modification, alike from the results of added experience, from larger means, and from the infusion of a wiser and more generous spirit. Doubtless more of economic, historical, and philosophical studies will be introduced to supplement, by their liberalizing tendencies, the work of the sciences in making their pupils exact and strong. Possibly some ultimate form for institutions of the higher learning may yet be developed, which shall embody much of both the modern school of technology and of the old-fashioned college, with, perhaps, something taken from neither, but originating in the larger, fuller, riper life of a happier and richer future.

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